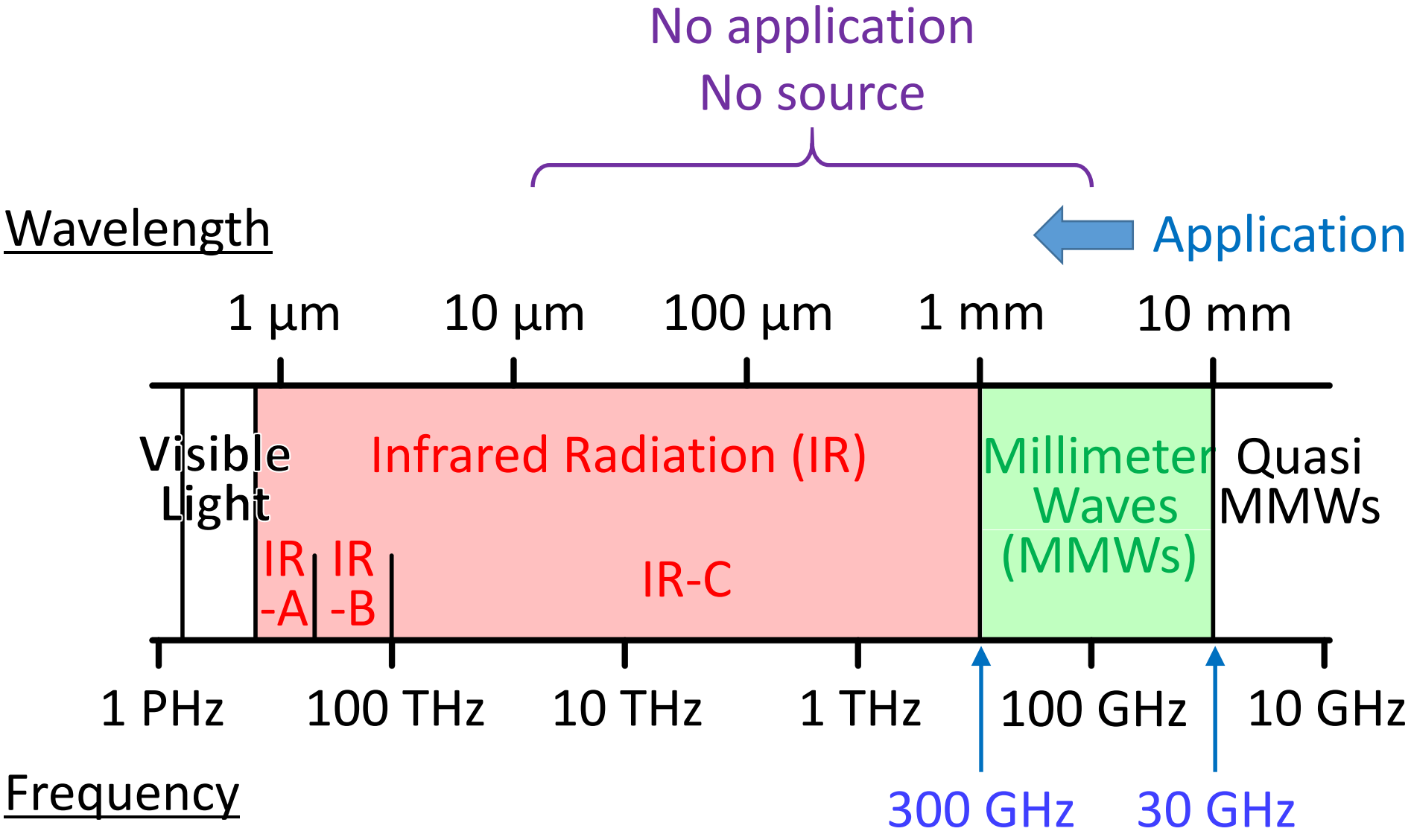
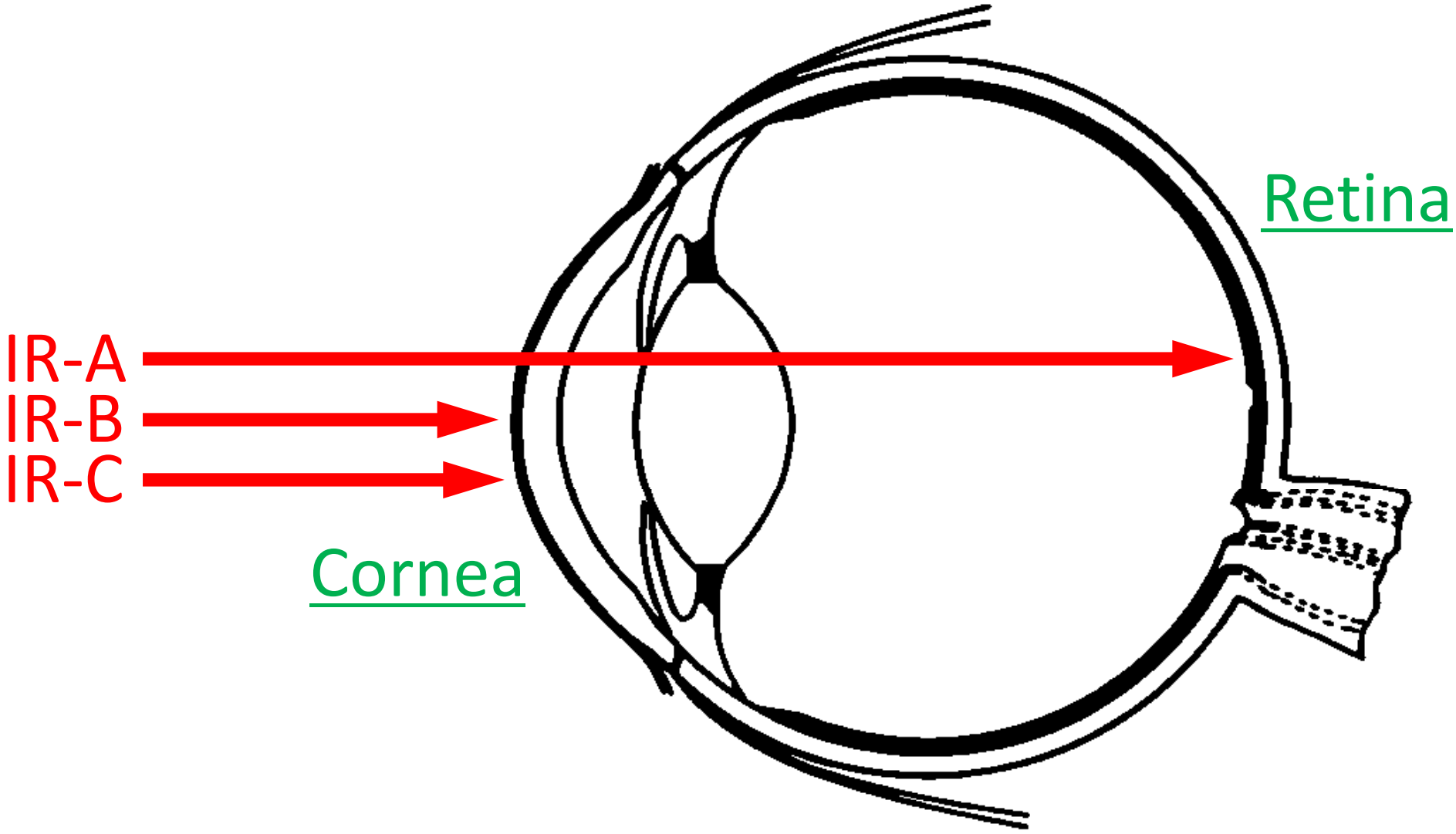
Issues to be considered when harmonizing the guidelines for infrared radiation and millimeter wave exposure

Tsutomu Okuno
Tokyo Metropolitan University

Spectrum of electromagnetic waves



Ocular effects of IR-A, IR-B and IR-C



Objective

To provide the information that is necessary when discussing harmonization of the IR and MMW guidelines

Contents

- Guidelines for IR
- Comparison between the IR and MMW guidelines
- Issues to be considered when harmonizing the IR and MMW guidelines

Laser IR versus ordinary (non-laser) IR

- Laser IR is IR of a single wavelength.
- Ordinary IR consists of components of different wavelengths.

- Different situations of emission
- Different situations of human exposure

→ Different guidelines

ICNIRP guidelines for IR

- Ordinary IR

  ICNIRP Guidelines on Limits of Exposure to Incoherent Visible and Infrared Radiation

  (Health Physics 105(1):74-96; 2013)

- Laser IR

  ICNIRP Guidelines on Limits of Exposure to Laser Radiation of Wavelengths between 180 nm and 1,000 μm

  (Health Physics 105(3):271-295; 2013)

Irradiance and spectral irradiance

Irradiance

➡ Power density

Power received by a surface per unit area.

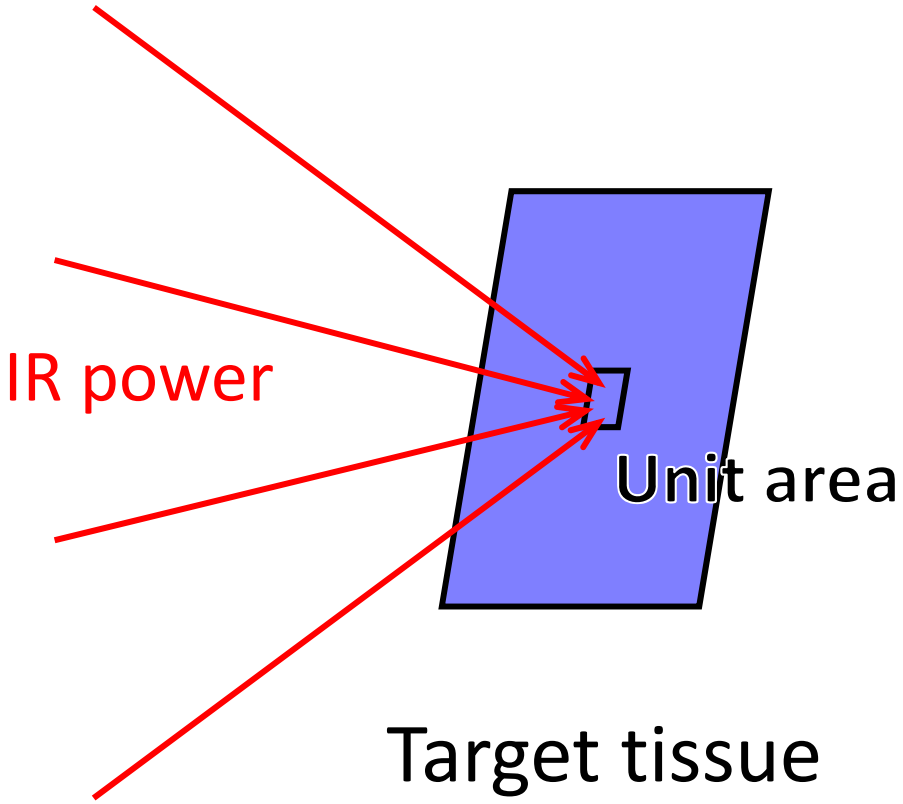
E (Wm^{-2})
($mWcm^{-2}$)

Spectral irradiance

Irradiance of a surface per unit wavelength

$E(\lambda)$ ($Wm^{-2}nm^{-1}$)
($mWcm^{-2}nm^{-1}$)

λ: Wavelength



Guidelines for ordinary IR

Wavelength: 1400 nm – 1 mm
Averaging area: 7 mm in diameter

- To avoid thermal injury of the cornea and possible delayed effects on the lens of the eye (cataractogenesis)

E_{IR}: Effective irradiance

$$E_{IR} = 0.3\int_{780\,nm}^{1000\,nm} E(\lambda)d\lambda + \int_{1000\,nm}^{3000\,nm} E(\lambda)d\lambda$$

t : Exposure duration

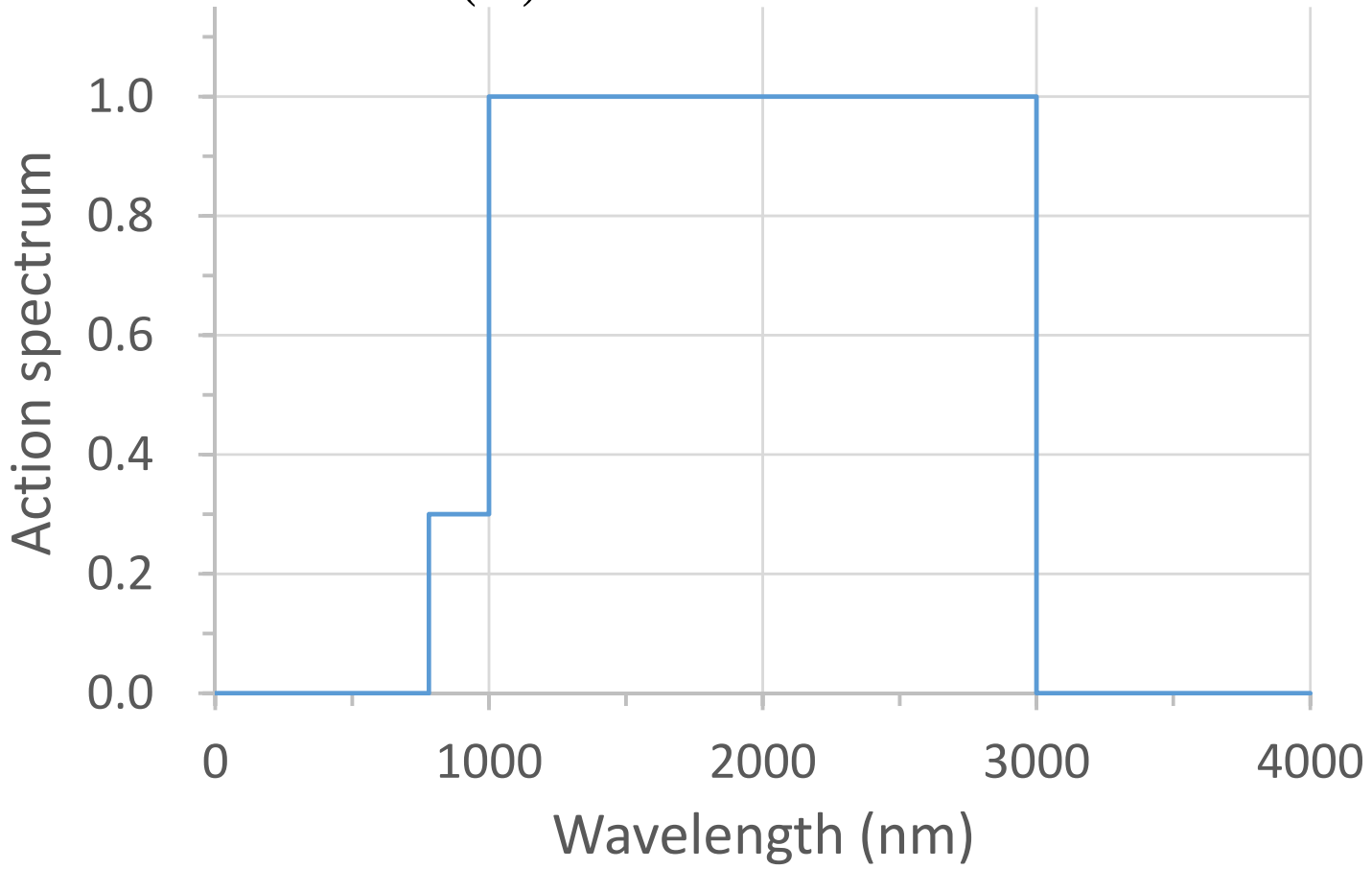
$$t < 1000\ s \qquad E_{IR} \le 18 \times t^{-0.75} \times 10^3\ Wm^{-2}$$

$$t \ge 1000\ s \qquad E_{IR} \le 100\ Wm^{-2}$$

Idea of action spectrum

$$E_{IR} = 0.3\int_{780\ nm}^{1000\ nm} E(\lambda)d\lambda + \int_{1000\ nm}^{3000\ nm} E(\lambda)d\lambda = \int_{780\ nm}^{3000\ nm} E(\lambda)A(\lambda)d\lambda$$

$A(\lambda)$: Action spectrum



Guidelines for ordinary IR

- To protect the skin from thermal injury

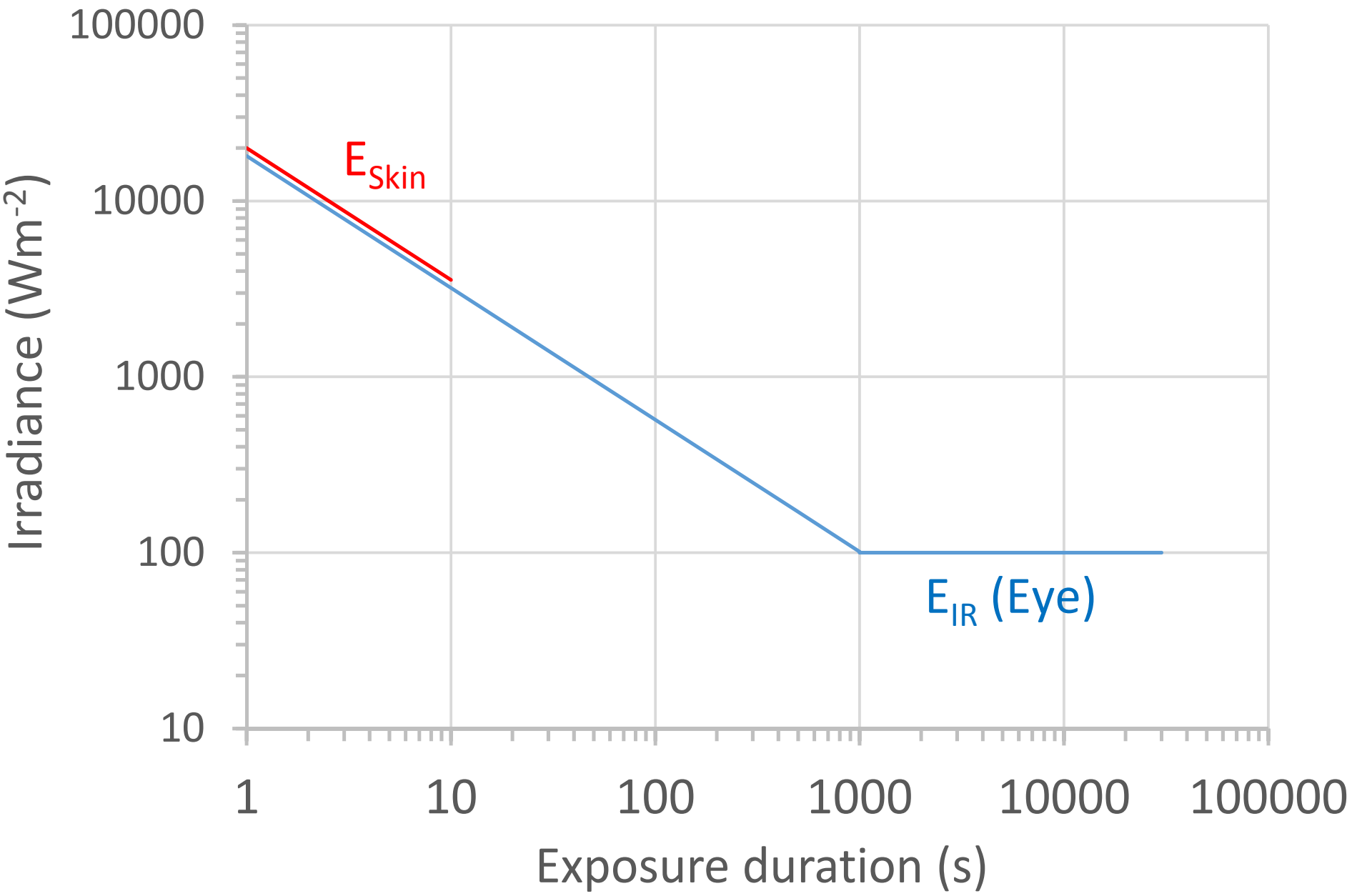
E_{Skin} : Effective irradiance

$$E_{Skin} = \int_{380\,nm}^{3000\,nm} E(\lambda) d\lambda$$

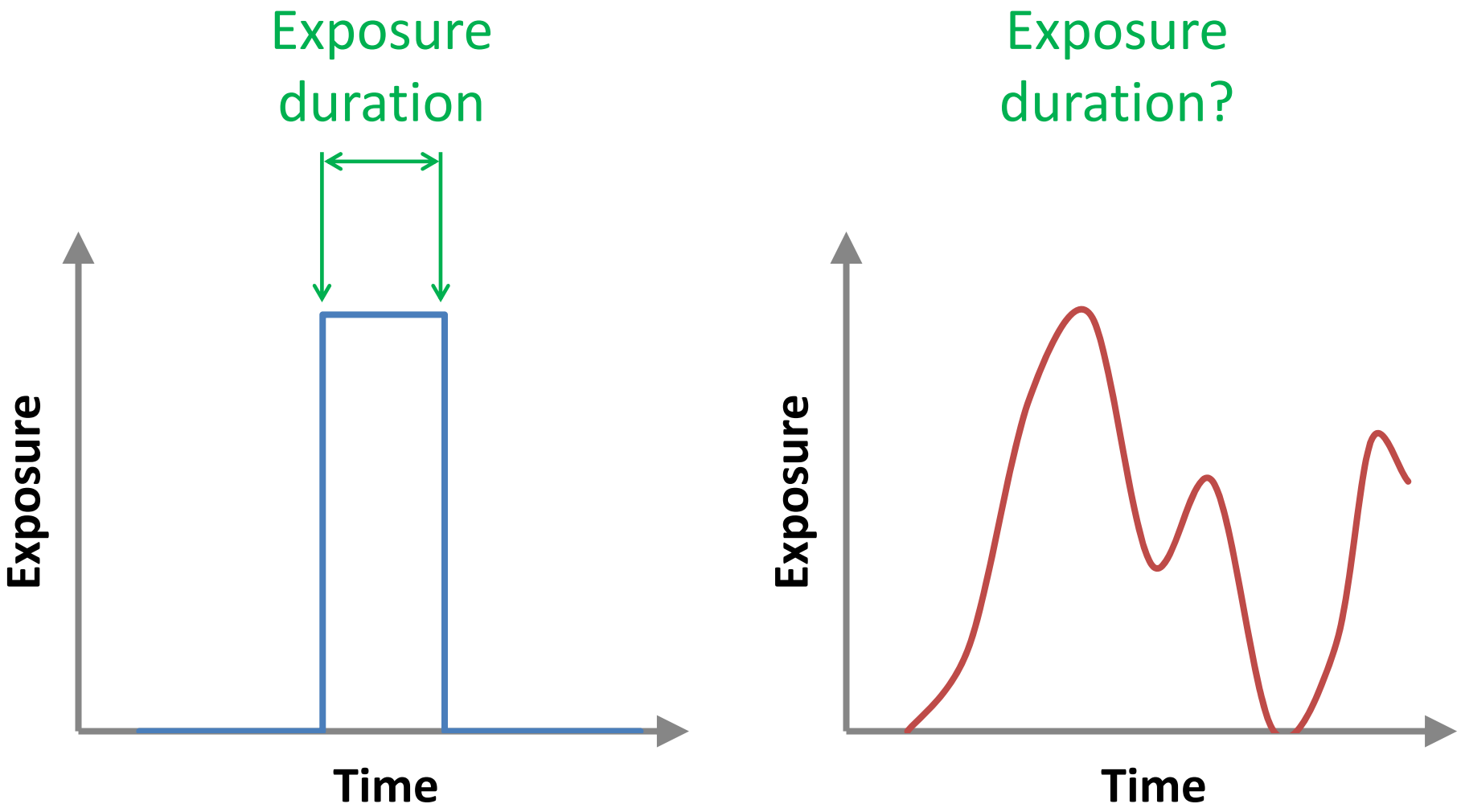
t : Exposure duration

$$t < 10\ s \quad \int_0^t E_{Skin}(t_1) dt_1 \le 2.0 \times t^{0.25} \times 10^4\ Jm^{-2}$$

Exposure limits for ordinary IR



Problem about exposure duration



Guidelines for laser IR (IR-B, IR-C)

Wavelength: 1400 nm – 1 mm

t : Exposure duration

- For eye exposure

$$10\ s < t < 30\ ks \qquad E \leq 1.0\ kWm^{-2}$$

Averaging area in diameter: 3.5 mm

- For skin exposure

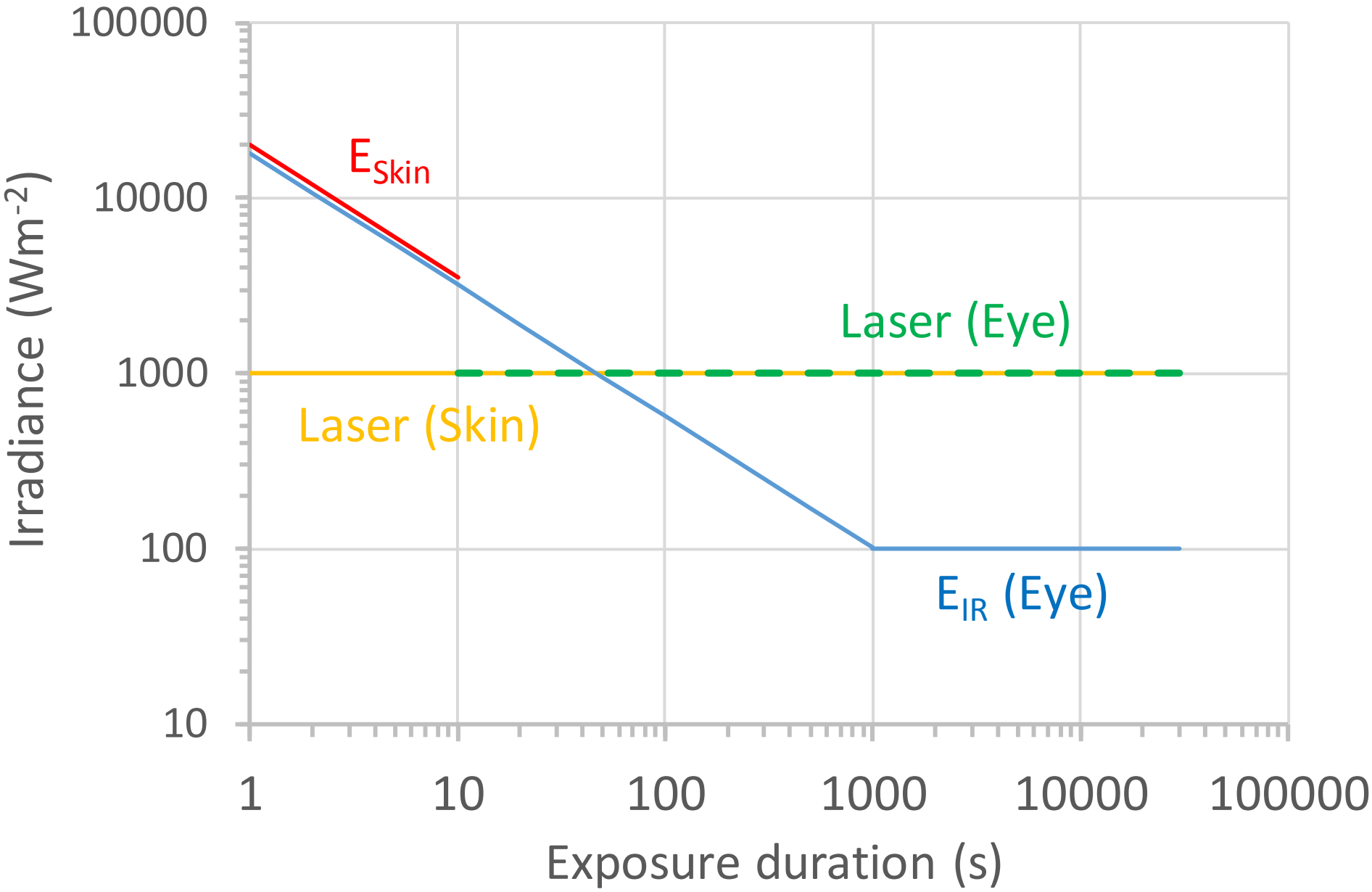
$$1\ ns < t < 30\ ks \qquad E \leq 1.0\ kWm^{-2}$$

Averaging area in diameter:

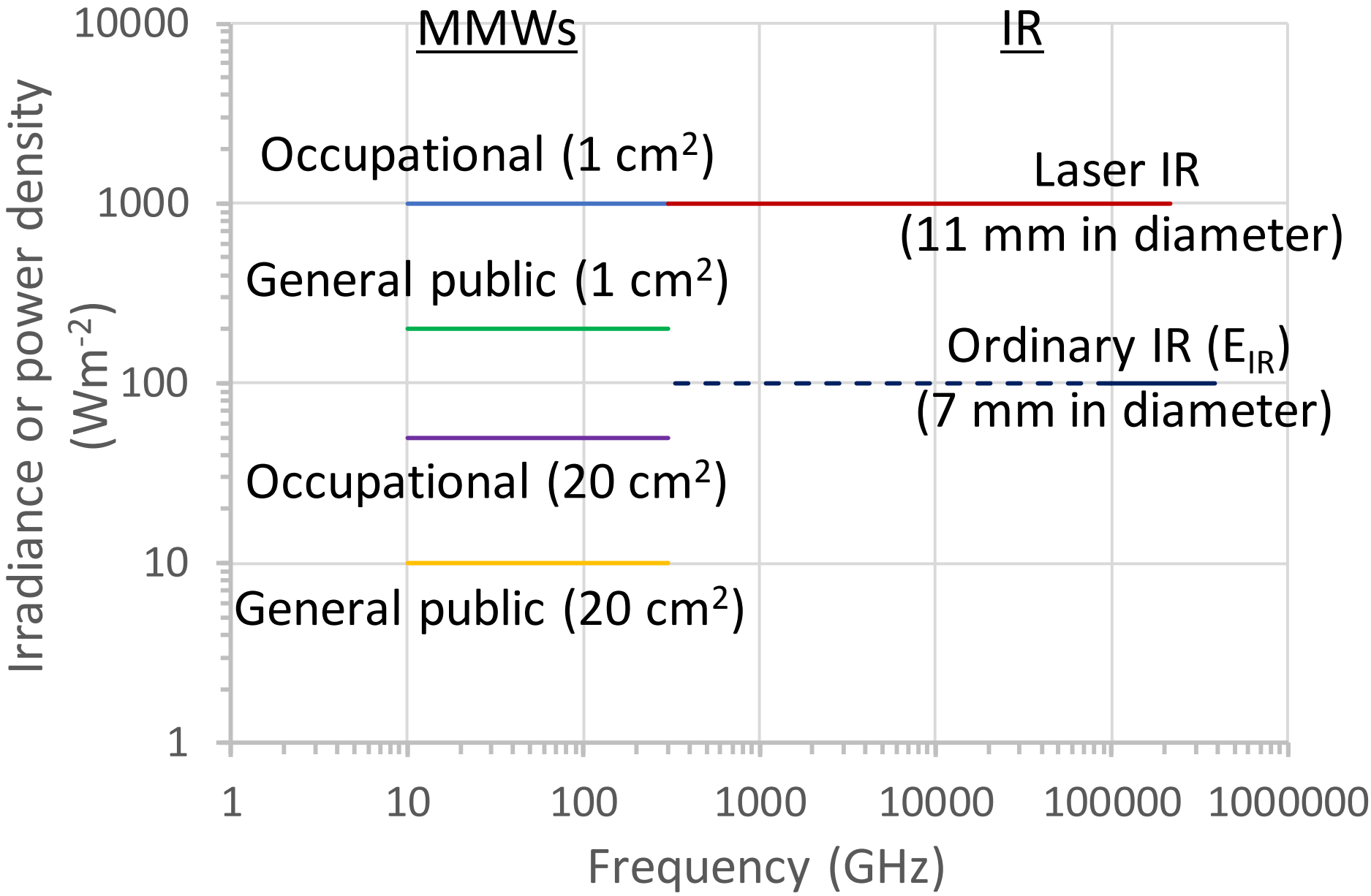
3.5 mm for 1400 nm – 0.1 mm

11 mm for 0.1 mm – 1 mm

Exposure limits for IR



Exposure limits for IR and MMWs

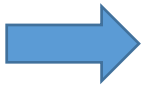


Comparison between the IR and MMW guidelines

	IR	MMWs
Exposure limits	mostly different	
Averaging area	different	
Averaging time	not considered	considered
Distinction between occupational and general public exposure	not considered	considered
Action spectra	considered	not considered

Other issues to be considered

- Both IR and MMW guidelines target the prevention of thermal injuries.
- Basically, the guidelines for IR are not interested in the long wavelength region.



These facts will work in favor of harmonization of the IR and MMW guidelines.